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Death from the Sky ?

"Regrettable" Violations of Rules of Warfare . . . Bombing to Shatter Morale of Civilians . . . Inaccuracy Makes the Airplane Bomb a More Fearful Weapon of Offense

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A BOMB released from an airplane has but a remote chance of hitting the prescribed objective. Many factors are involved in determining the flight of a bomb, several of which are either not known or are difficult to ascertain. In many cases, particularly during a daylight attack, the activities of enemy pursuit planes and anti-aircraft gunnery prevent a bomber from using even the scanty data available, and frequently compel him to "lay his eggs" without taking a sight at all. In night bombing, these interfering factors are partly eliminated but a "black-out" adds enormously to the bomber's difficulties. Not until he looks down, perhaps half a minute later, and sees the cloud of black smoke by day or the pin-point flash by night, does he realize "where that one went."

Knowledge of these facts makes aerial bombing a fearful weapon in the grasp of relentless modern commands. It allows them to commit crimes against hitherto established international rules of warfare; to kill or maim non-combatants; to destroy non-military structures. Under cover of the plea that his objective was a legitimate one, that his efforts were directed honorably, that the results—alas! so "regrettably" wide of his intentions—were accidental or unavoidable, a ruthless command may plan to shatter the morale of an enemy's civil existence in the hope of insuring indirectly an economical military conquest.

Within the past 25 years, airplanes have revolutionized the military and naval conduct of war. Their outstanding contribution to warfare admittedly lies in the sphere of reconnaissance—acquisition and transmission of intelligence. Airplanes are the eyes of a fleet or army, displacing the less agile sea-scout or destroyer and the relatively slow-motion cavalry. They constitute the gunners' range-finder for unseen craft and battery emplacements. They are the tipsters of the invisible knock-out.

TODAY the airplane has largely dissipated what the strategist aptly called the "fog of war" of yesterday. That it may be the means of creating a fog of its own, infinitely more disastrous than any fog yet conceived, is also probable. This we shall discuss later.

Such a valuable adjunct to land and sea forces must naturally create a rival. This appeared in the form of the fighter plane—a perfectly legitimate device—the object of which is to protect its own reconnaissance units and destroy those of the enemy. And so the airplane was transformed from a non-aggressive adjunct of the fighting forces to a weapon of offense. The next step in the evolution of the airplane as an offensive weapon was the attempt to make it simulate long-range artillery, resulting in the birth of the bomber. The projectile to be launched is comparable with that of a howitzer. The range of the aerial bomb corresponding to that of the latter is provided by the flight of the airplane but, instead of the projectile traveling throughout its flight in a calculable trajectory, like the howitzer shell, the aerial bomb is merely released with a velocity exactly equal to that of the plane at the time of release. In fact, we may regard the bomb as being fired from a platform at the height of the plane, the muzzle velocity of the bomb being the actual velocity of the plane relative to the ground.

The height of the plane above the objective is readily obtained from the altimeter reading, correcting, if necessary, for the elevation of the objective above sea level as indicated on a contour map. The determination of the velocity of the plane relative to the ground is a more difficult problem. It depends on the air-speed of the plane—that is, the speed at which the plane flies horizontally in still air—as well as on the velocity and direc-

Official photograph, U. S. Army Air Corps

Attack plane dropping gas bombs on "enemy" anti-aircraft battery during recent maneuvers

tion of the wind at the height of the plane. These last factors are characteristic of the spot *near* the objective *at the time* of release, and are usually not known with any degree of accuracy. Some idea of their value over the objective may be obtained by preliminary flights, or from balloon observations, at a safe distance from enemy interference —trusting, from judgment of weather conditions, that similar or only slightly modified conditions may exist over the objective.

NOW, if the bomber knows all details of air speed and ground speed, wind direction and velocity, it is possible for him to set his bomb-sight either for an upwind or downwind approach to the objective. The range—the horizontal distance between the objective and the position of the plane at the instant of release—will be very different (Figure 1) according as to whether the plane is flown up- or downwind. The trajectory of the bomb is approximately that of the parabolas shown. The diagram in Figure 1 represents the following concrete case:

Air-speed of plane = 150 miles an hour.
Height of plane above objective = 10,000 feet.
Wind velocity at this height = 30 miles an hour.
Ground-speed of plane (downwind) = 180 miles an hour; 264 feet per second.
Ground-speed of plane (upwind) = 120 miles an hour; 176 feet per second.
Theoretical range of bomb (downwind), OZ = 6600 feet.
Theoretical range of bomb (upwind), OZ_2 = 4400 feet.

The parabolic trajectory XZ would be traced by an ideal *streamlined* bomb released with its axis parallel to the line of flight and so stabilized that, in its forward and downward flight, it does not wobble. In actual practice, none of these conditions is realized. Most bombs are only approximately streamlined, except for their tail stabilizing fins, which, like the feathers of a dart, are necessary to prevent undue wobbling as the speed of descent increases and the curvature of the trajectory changes. No aerial bomb is favored with the stabilizing gyroscopic spin imparted to an artillery shell, as its copper band threads its way through a rifled bore. Therefore the bomb wobbles—it can be seen to do so as it leaves the plane—and in so doing it, in effect, becomes less streamlined. Owing to the resultant head-resistance, the horizontal speed of the bomb during each second of its fall is gradually reduced below that of the speed at the time of release. The plane keeps up this speed because of its engine power; the bomb, having no such propelling power to counteract the head-resistance, lags behind a direct vertical drawn through the plane.

From a height of 10,000 feet, a well streamlined bomb takes a little over 25 seconds to reach the ground. Each type of bomb has its own lag, and all that can be done to compensate for the intricate variants due to bomb shape, height and speed of plane, and so on, is to modify the height and time-scales of the sighting mechanism so as to allow for an average lag representative of an average-most-commonly-used type. This lag, ZZ, in Figure 1, is measured by dropping either dummy or unfused actual bombs.

A CAMERA obscura which, curiously enough, originated in the 13th Century through the genius of Roger Bacon, and which was conceived by him for developing the arts, may be used for measuring bomb lag. A sketch of this device is shown in Figure 2. It consists of a darkened chamber in the roof of which is inserted a convex lens L. Below the lens is a table on which is pinned a sheet of white paper, the distance from the center of the lens to the paper being equal to the focal length of the lens. Any object, say a cloud or an airplane, may be considered as at infinity and will form a sharp image on the paper. If a plane flies over the camera obscura in the direction AB, an image of it will move

Drawings by the author

Figure 1

across the paper in the opposite direction, *ab*. The pilot is instructed to fly upwind and downwind, these directions being obtained through use of the drift indicator. A metronome is set to beat one-second intervals and an observer places a pencil dot, at the beat of each second, on the image of the nose of the machine, tracing the image (Figure 3) in both its up- and downwind tracks. For the upwind track, the ground speed is low and the dots are close together; for the downwind track, the ground speed is high and the dots are far apart.

As the plane moves from A to B, the image moves from *a* to *b*, the similar triangles ABL and *ab*L (Figure 2) giving the scale of flight reduction by *ab*/AB = *a*L/AL. From this, knowing the

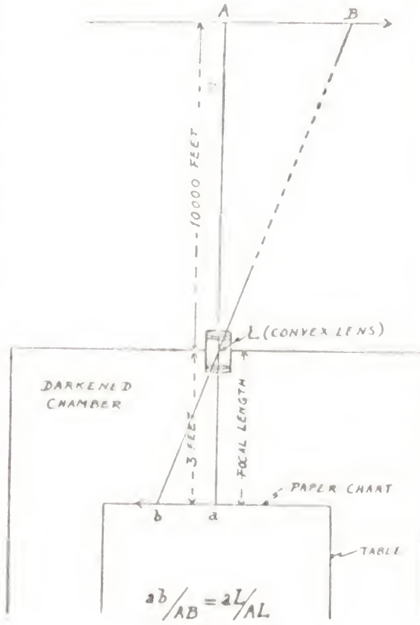

Figure 2

number of seconds required to trace the track *ab*, we get the ground speed, upwind and downwind, respectively. Suppose the bomber is aiming at a target, the bearing of which relative to the camera obscura O is marked to scale on the camera table. The bomber signals by radio the instant he releases the dummy bomb and the observer marks the instant of this signal at X (Figure 3) on the track of the plane's image. A tangent to the track at X gives the projection of the bomb's line of flight on the ground and the point of impact of a theoretically streamlined bomb is found by measuring a distance XZ equal to distance between second dots at X multiplied by time of descent of bomb in seconds. The actual point of impact of the dummy bomb is measured on the ground outside and its position transferred to the camera obscura chart. The difference between the range calculated and that measured gives the lag which is required. The average of about 20 tests gives a sufficiently accurate estimate of the lag, and allowance is made for this amount in the graduation of the sights

that are used on the bombing plane.

With these corrected sights, the bomber would now release his bombs (Figure 1) at X_1 instead of at X; that is, he would release late to compensate for shooting short due to the head-resistance of the bomb.

Even when every effort has been made to evaluate these variables, there still are unknown factors with which the bomber has to contend. From heights of 15,000 to 20,000 feet, now chosen by bombers, there is little to fear from anti-aircraft guns; but as height increases, errors increase, and prevailing air currents in lower strata of the atmosphere may even oppose those above. Enemy pursuit planes have still to be faced. They are faster and can fly still higher, harassing the bombers at critical moments and vitiating their aim.

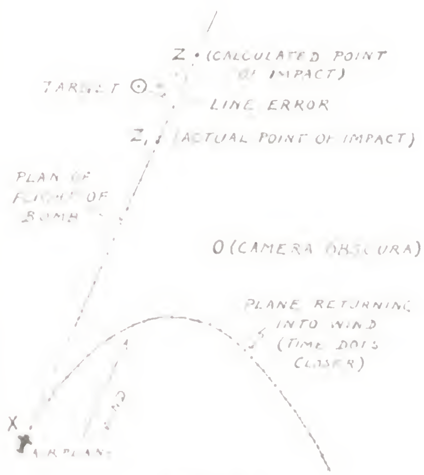

Figure 3

Errors of the order of 20 percent in range, over or short, also right or left, of an objective are common; this percentage is usually greatly exceeded under exigencies of war where the bomber is threatened with attack. On a range of 5000 feet, the minimum error may be set at 1000 feet north, south, east, and west of a target. Quite large buildings are therefore too small, as individual objectives, to be hit by direct skilful sighting. More reasonable objectives are dockyards, large camps, factories, and aerodromes.

During the World War and in a few recent attacks, bombs have been launched while diving to low altitudes. As in the case of low-altitude machine gunning, this practice eliminates almost all the unknown variables referred to above, the line of flight of the bomb being approximately the line of flight of the machine over its short trajectory as shown in Figure 4. In such cases the bombs must be equipped with delay fuses to allow the bomber time to zoom clear before explosion takes place. The risks entailed by low-altitude bombing, except in the cases of attacks on unarmed populations or savage tribes, are too great to make this a popular mode of aerial attack. In most of the calamitous raids of the last two or three years, greater and greater altitudes have indicated a growing respect for the defender. And poorer and poorer become the efforts of the attacker until we may say that they have ceased to be discriminative!

Another way of reducing the uncertain factors affecting the trajectory of a bomb is that based on the vertical dive. A plane diving vertically will reach a terminal velocity of 500 to 600 miles an hour. At this speed the upward head-resistance counterbalances the weight of the plane and the plane falls without further gain of speed. This is approximately the speed at which the bomb of Figure 1 strikes the ground. Such a speed would not add appreciably to the accuracy of bombing, but it would have very serious effects on a pilot's endurance in executing the maneuver out of the dive, to say nothing of the probable collapse of his machine! Such vertical speeds can be avoided by taking advantage of the reversible pitch propeller. With this, the vertical speed downward can be reduced to approximately the speed of horizontal flight. In dive bombing of this type, the bomber executes his dive vertically above the target—a definite drawback to the method. In bombing from horizontal flight, the bomber need not approach his target much closer than a mile, and, immediately he has released his bombs, he may bank away and return to his aerodrome.

THE vertical dive method only partly solves the difficulties of the bomber. A plane so falling is still drifting with an uncertain wind velocity. For example, in the concrete case cited above, a wind drift of 30 miles an hour is assumed. If this is not allowed for, a bomb released when diving at 10,000 feet will drift about 1100 feet from the vertical; that is, from the target. Here is very large error when the dangerous maneuvers involved are taken into consideration! In addition, the acknowledged military advantages of formation flying would be sacrificed, at least during and subsequent to the dive.

The use of bombing airplanes as long-range heavy-artillery units has completely revolutionized warfare, particularly in the early stages of attack. The

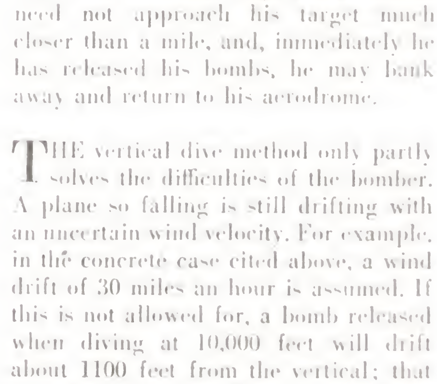

Figure 4

Official photograph, U. S. Army Air Corps

Loading a dummy "bomb" preparatory to conducting camera obscura tests as described

inception of the reconnaissance plane automatically dispersed the then extant "fog of war." Reprisals against this efficient reconnaissance system have resulted in plane armament, finally evolving a purely offensive plane—the long-range bomber, whose swift, unascertainable deployment has created a higher, wider, deeper, and more impenetrable "fog of war" than mankind has ever hitherto conceived. This new monster is the more terrifying because the very fog itself is the destroyer. Some of the powers that embrace this unbridled scourge on humanity will not stop at high explosive and incendiary bombs. The policy to which they are addicted demands the destruction of all and sundry—annihilation! The aim of aggressors is to add to the new "fog of war" every destructive agency that can be adapted to military use. Experiments in earmarked laboratories and over selected flying areas are reported to be making rapid advances toward this monstrous achievement.

The bewildered man-in-the-street may well ponder: "Will the airplane, and particularly the modern long-range bomber, succeed as a unit of offense?" It appears that certain present-day high commands are willing to gamble on the effect of thrusting the hellishness of war directly into the faces of civilian populations. Thus they hope that these helpless people may be forced to plead for even unconditional surrender of rights so that the way will be paved for a cheap military victory.

On the other hand, this modern and inhuman way of conquest may have precisely the opposite effect. It may stiffen backs under the goad of pitiless slaughter of compatriots and engender a potential vengeance which one day will result in an eclipse of the ephemeral military conquest.

Although the outcome of the airplane offensive by means of aerial bombings remains an unknown, indeterminate quantity, the world may be sure that the unwholesome atrocities which are happening today are but curtain-raisers on insane dramas to come.